SF Environment

Our home. Our city. Our planet.

A Department of the City and County of San Francisco

ARUP

COMMUNITY INTEGRATED RENEWABLE ENERGY (CIRE)

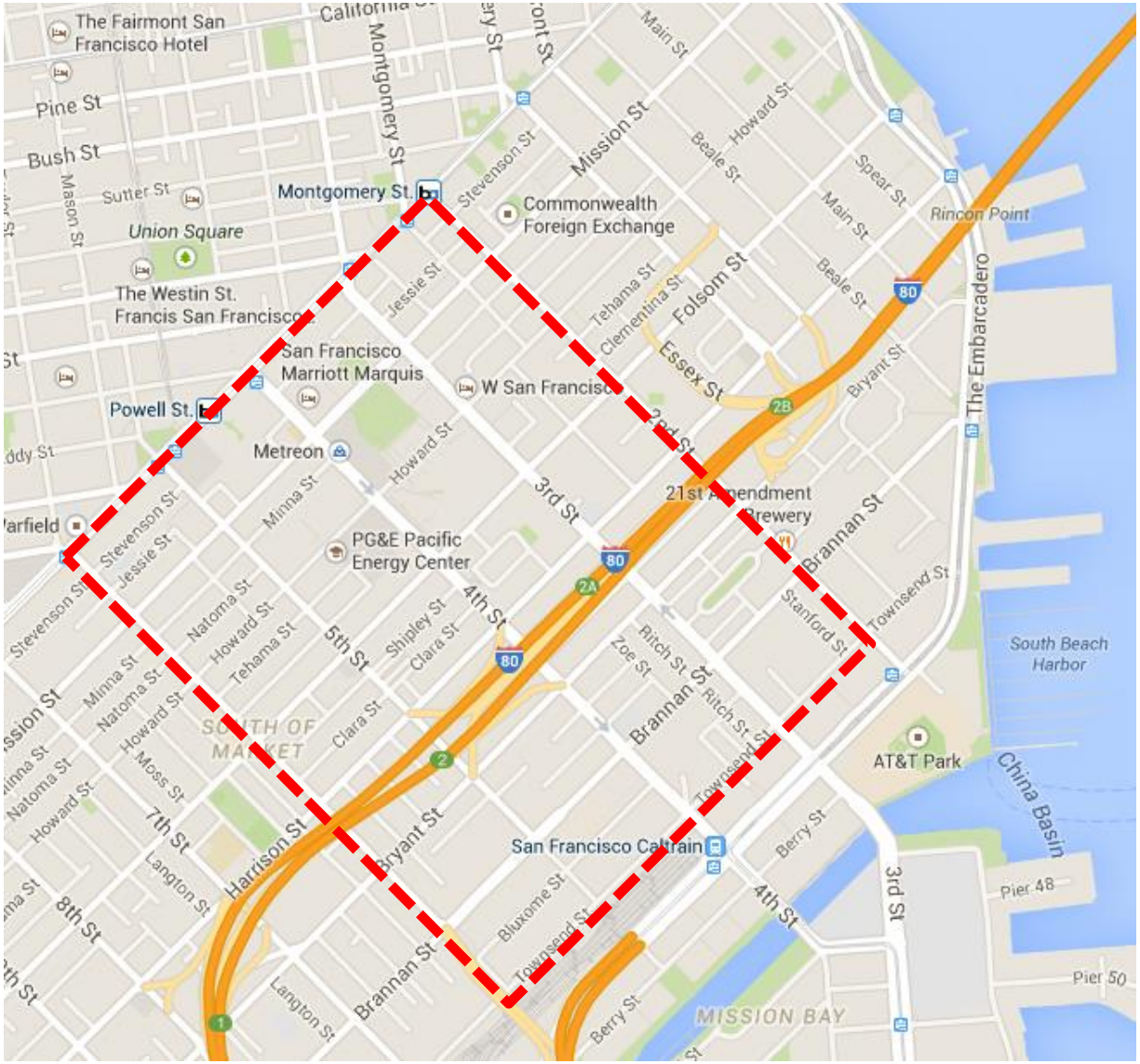
Project Findings

Project Summary

Regulatory | Technical | Economic

- Community Energy
- Integrating District Heating/Cooling
- Renewable Electricity
- Storage
- Demand Response
- Smart Distribution Technology

Study Area: San Francisco Central Corridor



Central Corridor:

- Significant rezoning
- Designated eco-district
- New subway
- 10,000 new housing units
- 35,000 new jobs

Source: Google Maps

Findings – By Task

Credit: Luminalt

Task 2a: DG Regulatory Policy

Task 1
- **Project Summary Report**

Task 2
- **Community-Distributed Generation**
  - **2a: Regulatory Policy**
  - 2b: Technical and Cost Impacts

Task 3
- **Community Energy and Enabling Technologies**
  - 3a: Electricity Use Case
  - 3b: Heat Use Case

Task 4
- **Energy Storage and Generation Analysis**

Task 5
- **District Thermal Energy Concepts**

Task 6
- **CIRE Potential Quantification**

Task 7
- **Dissemination**

Task 2a: DG Regulatory Policy

Findings

Barriers:

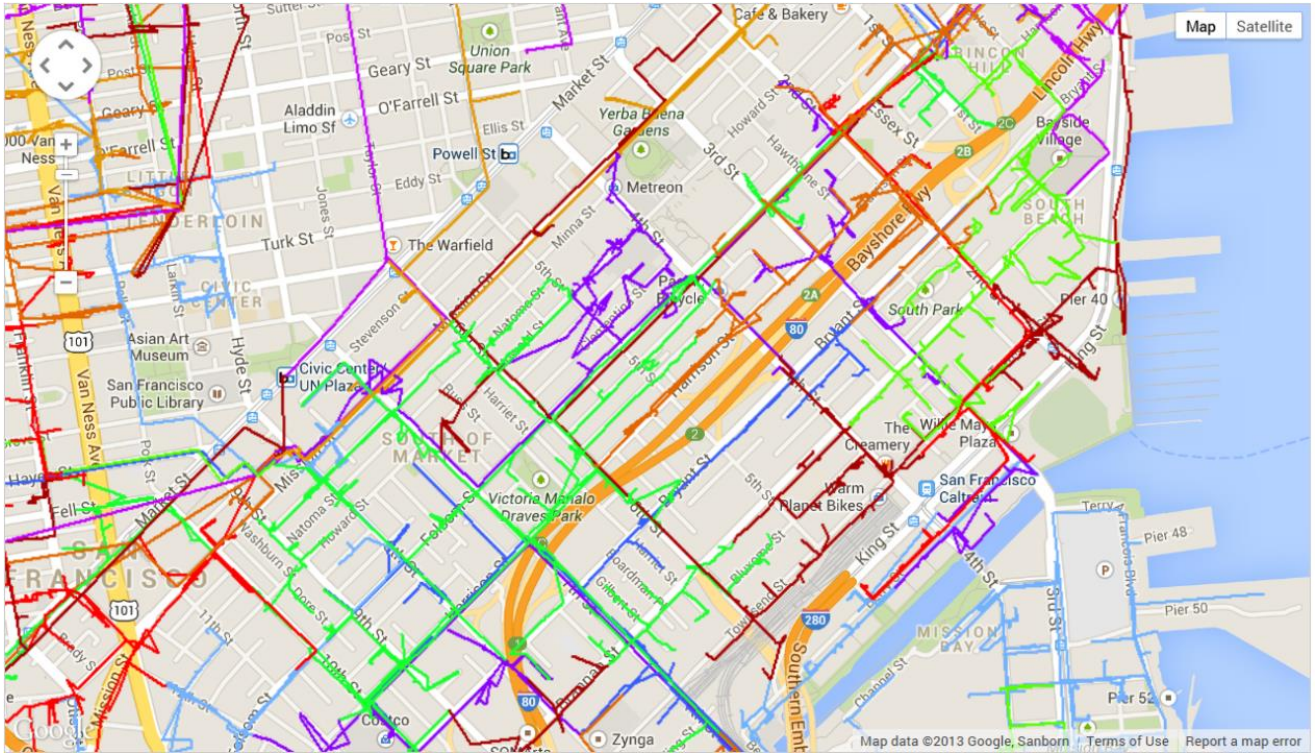
- Need to be utility when distributing to >2 entities
- Ownership of generation/distribution assets
- Existing electricity rate structure
- Incumbent utility business models and regulation

Opportunities:

- Senate Bill 43
- New rate for campus generation
- Multi-owner districts and microgrids

Task 2b:Technical and Cost Impacts

Scenarios



1. **Standard Network**
   a. 100kW
   b. 500kW
   c. 1MW
   d. 10MW

2. **Secondary Network**
   a. Low-voltage

Task 2b: Technical and Cost Impacts

Findings

Barriers/Break Points:

- Generation >15% peak load
- Generation requiring upgrades/back-feeds a utility transformer
- Any connection to secondary network

Solutions:

Standard Distribution Network

- Procure pre-application report during feasibility process

Secondary Network

- Allow export toward 100% of minimum load
- Install minimum import relay or reverse power relay
- Install a dynamic controlled inverter system

Project Tasks

Task 1
- **Project Summary Report**

Task 2
- **Community-Distributed Generation**
  - 2a: Regulatory Policy
  - 2b: Technical and Cost Impacts

Task 3
- **Community Energy and Enabling Technologies**
  - **3a: Electricity Use Case**
  - 3b: Heat Use Case

Task 4
- **Energy Storage and Generation Analysis**

Task 5
- **District Thermal Energy Concepts**

Task 6
- **CIRE Potential Quantification**

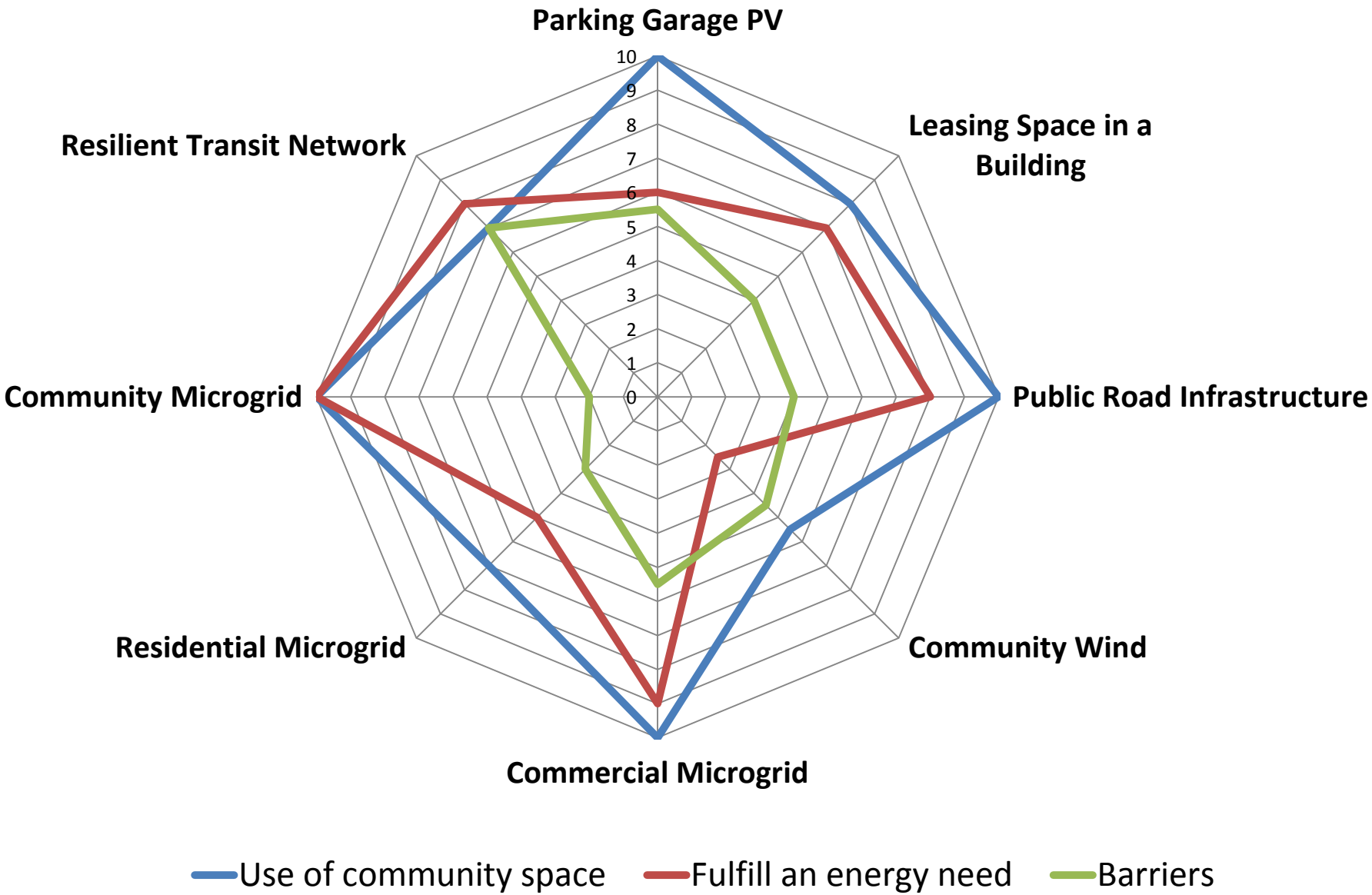
Task 7
- **Dissemination**

Task 3a: Electricity Use Case

Host workshop to engage community members and collect feedback on two scenario categories:

1. **Community energy scenarios**
2. **Enabling technologies to allow generation to operate in a grid outage**

Task 3a: Electricity Use Case



Task 3a: Electricity Use Case

Findings - Community Solar

High-value sites

Parking garages

- EV charging, can generate revenue

Public road infrastructure

- being studied by DoT

Barriers

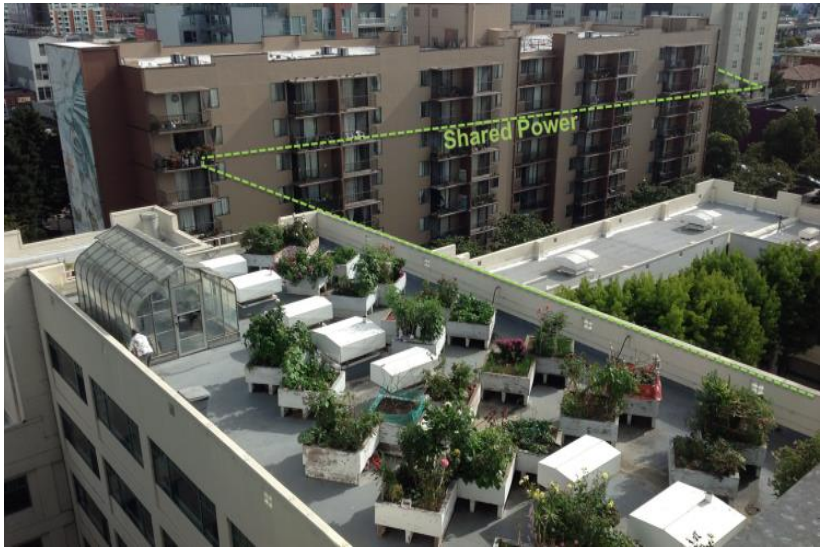
Transmitting energy across public rights-of-way/shared ownership

- Recommend studies performed with IOUs and Regulators
- Recommend Campus Rate

Task 3a: Electricity Use Case

Findings - Enabling Technologies

- Orchestrator needed to manage supply, demand, safety, and reconnection
- Job best suited to existing IOU or third-party energy provider



Project Tasks

Task 1
- **Project Summary Report**

Task 2
- **Community-Distributed Generation**
  - 2a: Regulatory Policy
  - 2b: Technical and Cost Impacts

Task 3
- **Community Energy and Enabling Technologies**
  - 3a: Electricity Use Case
  - **3b: Heat Use Case**

Task 4
- **Energy Storage and Generation Analysis**

Task 5
- **District Thermal Energy Concepts**

Task 6
- **CIRE Potential Quantification**

Task 7
- **Dissemination**

Task 3b: Heat Use Case

Task Scope

Engage in collaborative workshop with NRG to collect feedback on the potential of CIRE in existing district heating systems

Task 3b: Heat Use Case

Findings

1. Renewable Fuel

- Without identified local suppliers, biogas currently infeasible
- Biomass opportunity limited due to spatial constraints
  - Single boiler retrofit to support tri-fuel capability possibility

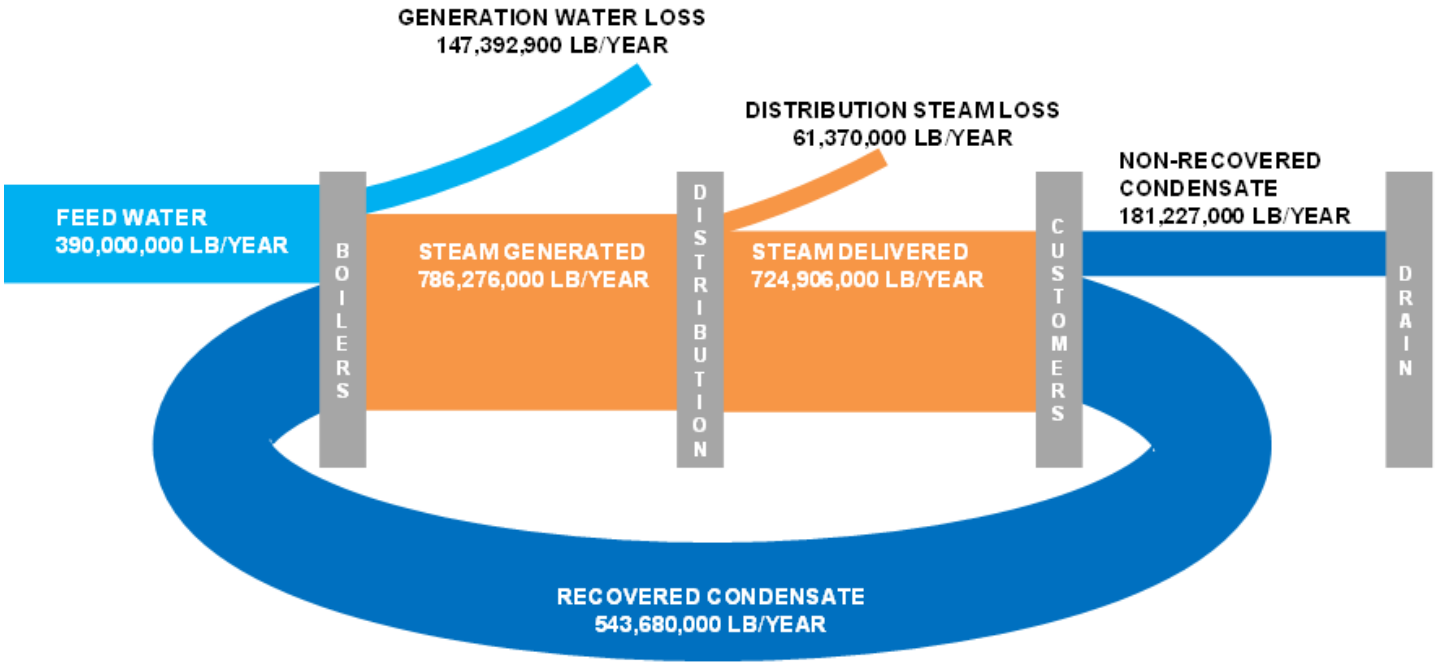
2. Solar Thermal System

- Boiler feedwater preheating most efficient configuration, but limited roof space and significant shading
- Systems could be integrated to heat condensate along return path

Task 3b: Heat Use Case

3. Condensate Recovery

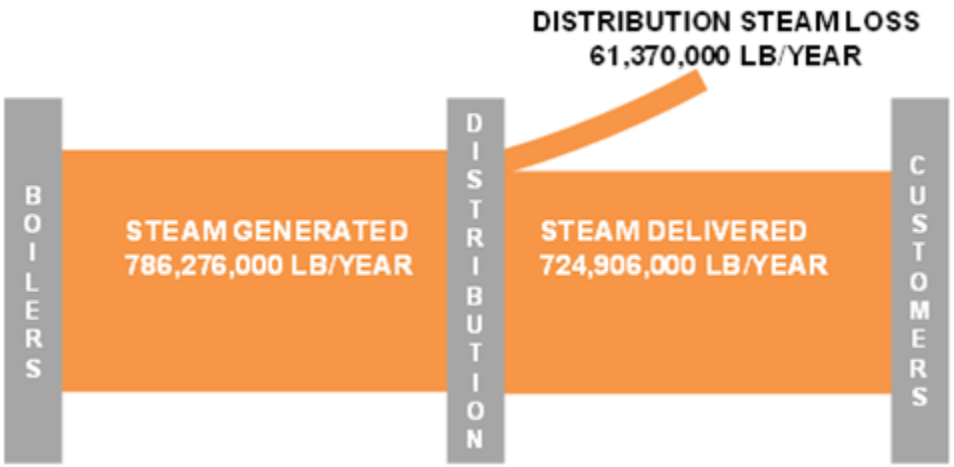
- NRG system currently recovers 12%-15% spent steam
- Undertaking expansion to increase recovery rate to approx. 50%
- Increasing to 75% represents a high cost with only moderate water and energy reduction benefit



Task 3b: Heat Use Case

4. Pipe Insulation and Repair

- Approx. 10 miles of piping
- 8% steam generated lost to leaks
- Maintenance/improvement feasible but "moderate" cost and benefit



5. Combined Heat and Power

- 500kW CHP project to begin operation mid-2014
  - Heat to be utilized for boiler feedwater preheating
- Alternately, could install large CHP to meet thermal base load of plant

Task 3b: Heat Use Case

6. Groundwater Recovery

- Attractive strategy for NRG
- Three existing neighboring sites already removing groundwater

7. Recycled Water

- Can be used in lieu of potable water for boiler feedwater or cooling towers
- Availability and pricing of "purple pipe" in the vicinity dictates feasibility
- "Green energy customer" scheme should be explored if costs are prohibitive

Project Tasks

Task 1
- **Project Summary Report**

Task 2
- **Community-Distributed Generation**
  - 2a: Regulatory Policy
  - 2b: Technical and Cost Impacts

Task 3
- **Community Energy and Enabling Technologies**
  - 3a: Electricity Use Case
  - 3b: Heat Use Case

Task 4
- **Energy Storage and Generation Analysis**

Task 5
- **District Thermal Energy Concepts**

Task 6
- **CIRE Potential Quantification**

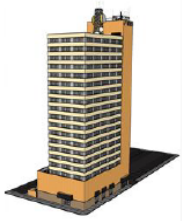
Task 7
- **Dissemination**

Task 4: Energy Storage/Generation Analysis

Considered 72 scenarios:

Scale x3 | Resilience x2 | Generation + Storage x12

Convention Center



Single Building

Community

5 hour Outage

72 hour Outage

1			☀				🔋					
2			☀					🔋				
3			☀							🔋		
4		⚙	☀				🔋					
5		⚙	☀					🔋				
6		⚙	☀							🔋		
7			☀	⚡			🔋					
8			☀	⚡				🔋				
9			☀	⚡						🔋		
10		⚙	☀	⚡			🔋					
11		⚙	☀	⚡				🔋				
12		⚙	☀	⚡						🔋		

⚙ Diesel Generator

☀ Photovoltaic (PV)

⚡ Fuel Cell

🔋 Lithium Ion Battery (Li-ion)

Liquid Air Energy Storage (LAES)

Flow Battery

Task 4: Energy Storage/Generation Analysis

Findings

- Limited space for renewables/storage
- Fixed-output generation (diesel generators/fuel cells) important for resilience
- Diesel limited to 24 hrs; larger capacity needed for longer outages
- Lithium batteries most feasible in size, but highest cost
- Community scale has lower cost of energy, better PV economics and more feasible storage solutions

→ **Greater resilience opportunities and economics of scale at community scale**

Project Tasks

Task 1
- **Project Summary Report**

Task 2
- **Community-Distributed Generation**
  - 2a: Regulatory Policy
  - 2b: Technical and Cost Impacts

Task 3
- **Community Energy and Enabling Technologies**
  - 3a: Electricity Use Case
  - 3b: Heat Use Case

Task 4
- **Energy Storage and Generation Analysis**

Task 5
- **District Thermal Energy Concepts**

Task 6
- **CIRE Potential Quantification**

Task 7
- **Dissemination**

Task 5: District Thermal Energy Concepts

Findings
(Indicative Case Example)

- Comparable capital costs, lower operating costs
- Net present cost reduction around 20%
- Environmental benefits
- Social benefits - community/public space
- Owner/developer buy-in greatest challenge

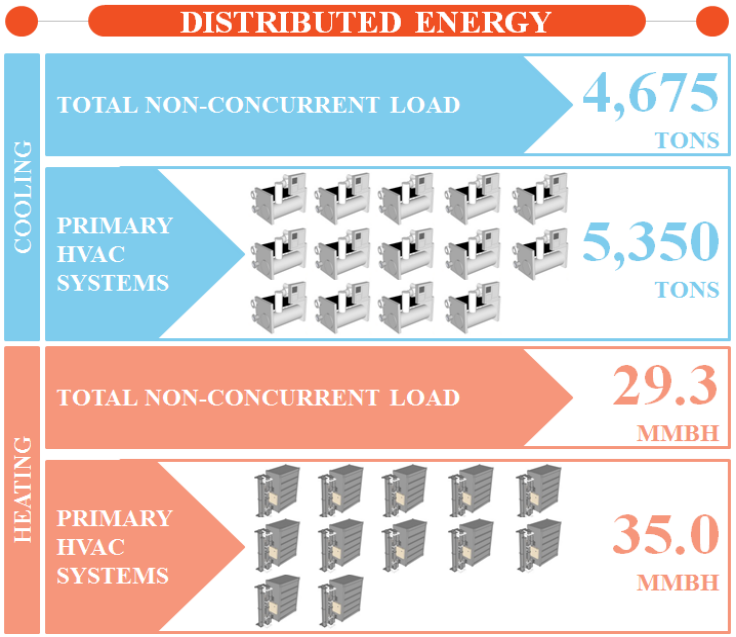
Task 5: District Thermal Energy Concepts

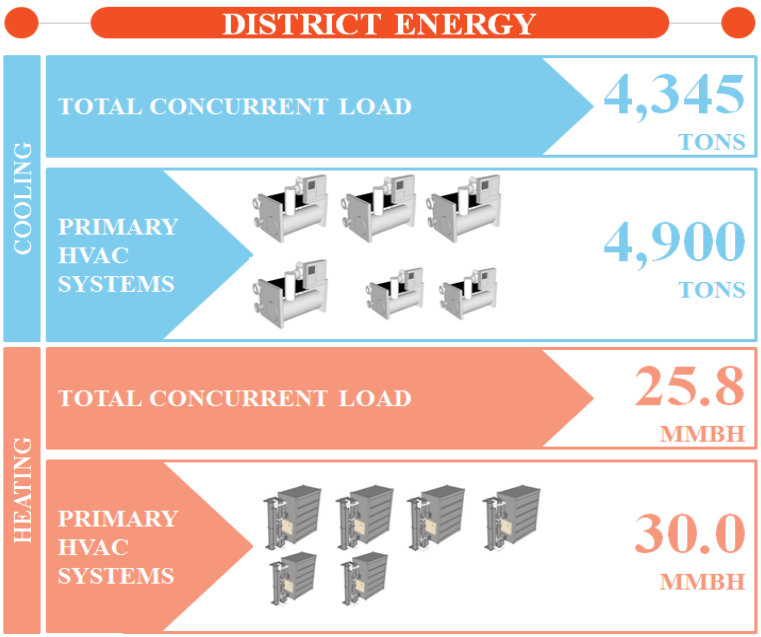
Community Thermal System	GHG REDUCTION POTENTIAL	WATER REDUCTION POTENTIAL	TOTAL ENERGY	TOTAL ENERGY COST	CAPEX	OPERATIONS & MAINTENANCE	PARCEL PLANT SIZE	CUP SIZE	PERMIT/APPROVAL RISK	DISTRIBUTION COMPLEXITY	RESILIENCE	COMMERCIAL RISK	WEIGHTED SCORE
BAU | DISTRIBUTED HEATING & COOLING	1.0	1.0	1.0	3.0	5.0	1.0	1.0	5.0	5.0	5.0	2.0	5.0	94.0
OPTION 1 | CENTRAL HEATING & COOLING	3.0	5.0	2.0	5.0	3.0	4.0	3.0	2.0	2.0	2.0	2.0	3.0	110.0
OPTION 2 | CENTRAL COOLING, DISTRIBUTED HEATING	3.0	5.0	2.0	5.0	4.0	4.0	4.0	4.0	3.0	3.0	2.0	3.0	123.0
OPTION 3 | WSHP + CONDENSER WATER NETWORK	5.0	5.0	5.0	1.0	4.0	3.0	2.0	2.0	3.0	3.0	3.0	3.0	128.0
OPTION 4 | COGEN + CENTRAL HEATING AND COOLING	3.0	5.0	2.0	5.0	2.0	2.0	3.0	1.0	1.0	1.0	5.0	2.0	104.0
OPTION 5a | TRIGEN (Heating prioritized) + CENTRAL HEATING AND COOLING	3.0	5.0	2.0	5.0	2.0	2.0	3.0	1.0	1.0	1.0	5.0	2.0	104.0
OPTION 5b | TRIGEN (Cooling prioritized) + CENTRAL HEATING AND COOLING	3.0	5.0	2.0	5.0	2.0	2.0	3.0	1.0	1.0	1.0	5.0	3.0	106.0
OPTION 8 | CENTRAL HEATING AND ENERGY RECOVERY CHILLERS	**5.0**	**5.0**	**5.0**	**5.0**	**3.0**	**4.0**	**3.0**	**3.0**	**2.0**	**2.0**	**2.0**	**4.0**	**136.0**
WEIGHTING	5.0	4.0	4.0	3.0	3.0	3.0	1.0	2.0	2.0	3.0	4.0	2.0	

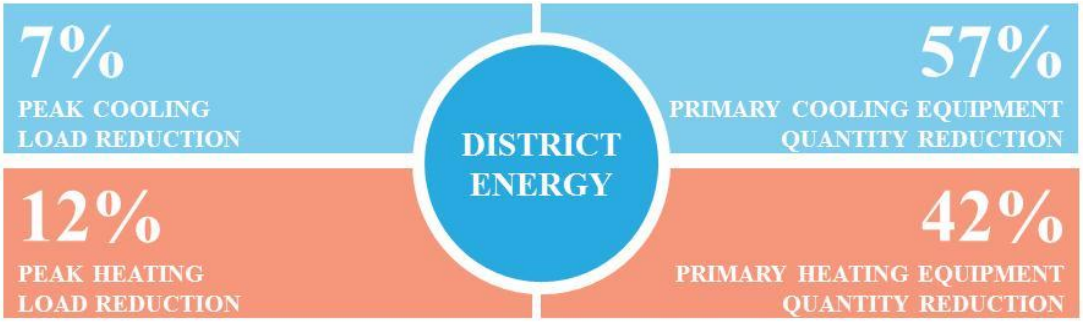
Legend	
1	Least favorable, Least Important
5	Most favorable, Most important
	Quantitative indicators
	Qualitative indicators

Task 5: District Thermal Energy Concepts

Load/Equipment Reduction

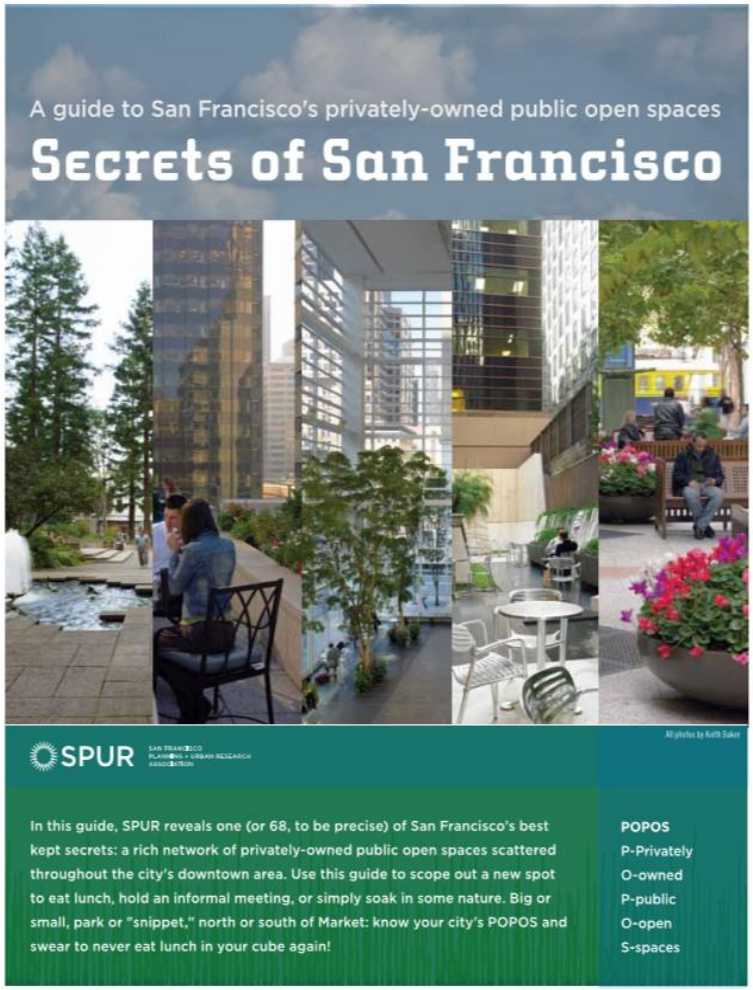


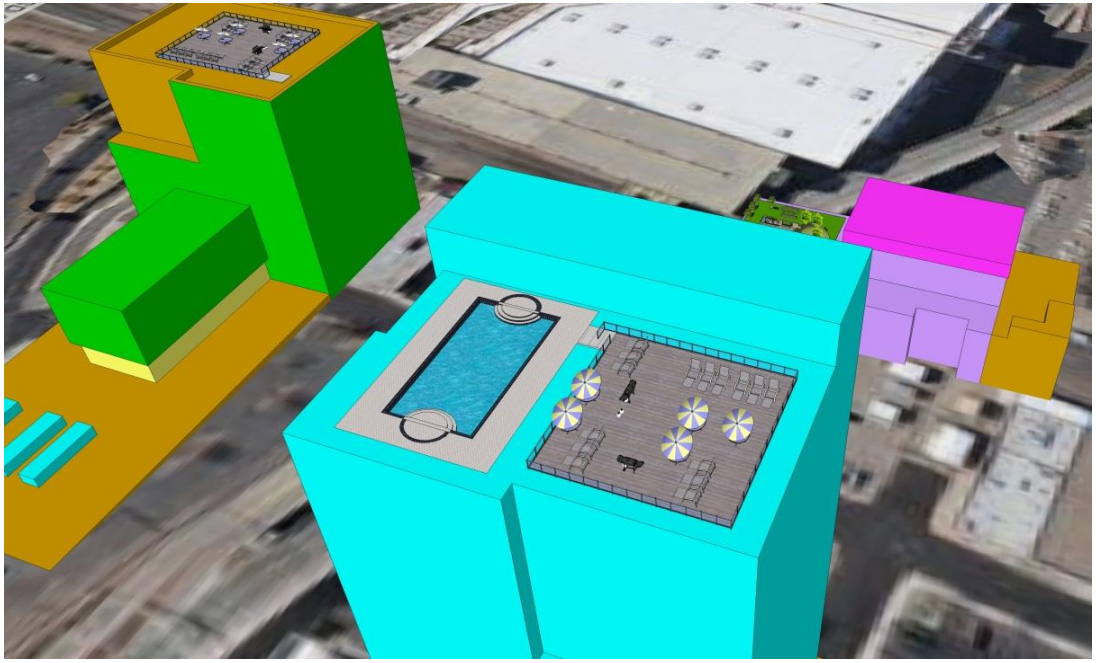


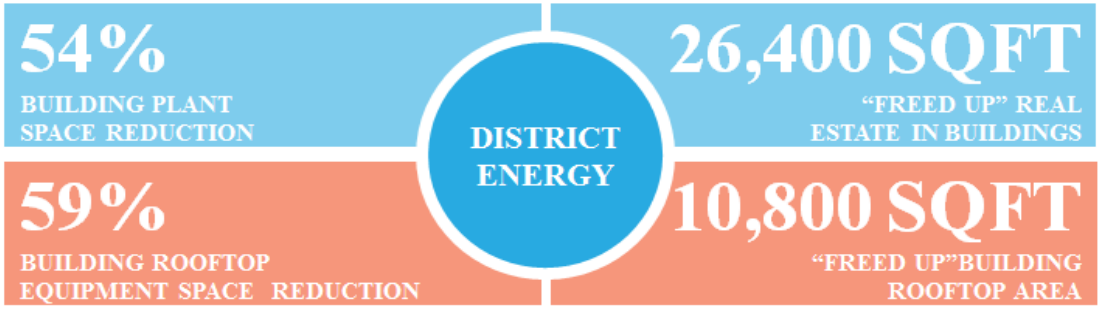


Task 5: District Thermal Energy Concepts

Social Benefits







Project Tasks

Task 1
- **Project Summary Report**

Task 2
- **Community-Distributed Generation**
  - 2a: Regulatory Policy
  - 2b: Technical and Cost Impacts

Task 3
- **Community Energy and Enabling Technologies**
  - 3a: Electricity Use Case
  - 3b: Heat Use Case

Task 4
- **Energy Storage and Generation Analysis**

Task 5
- **District Thermal Energy Concepts**

Task 6
- **CIRE Potential Quantification**

Task 7
- **Dissemination**

Task 6: CIRE Potential Quantification

Findings

Implementation of CIRE technologies could have a positive impact on California's energy costs, environment, and employment numbers:

Estimated over the life of projects

- **750,000 GWH** of electricity savings
- **12,000,000 therms** of gas savings
- **152,000,000 tons** CO_2 eq. emissions reduced
- **1,100,000 jobs** created

Project Tasks

Task 1
- **Project Summary Report**

Task 2
- **Community-Distributed Generation**
  - 2a: Regulatory Policy
  - 2b: Technical and Cost Impacts

Task 3
- **Community Energy and Enabling Technologies**
  - 3a: Electricity Use Case
  - 3b: Heat Use Case

Task 4
- **Energy Storage and Generation Analysis**

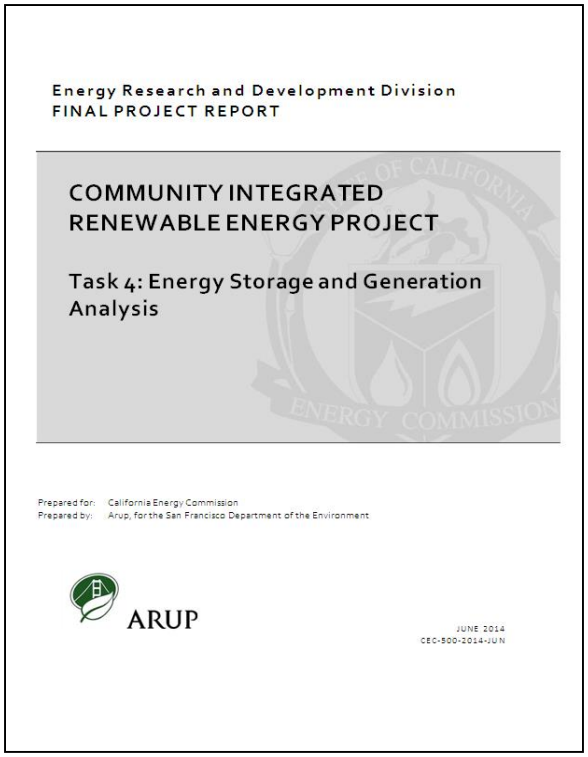
Task 5
- **District Thermal Energy Concepts**

Task 6
- **CIRE Potential Quantification**

Task 7
- **Dissemination**

Task 7: Dissemination

Roadmap documenting the barriers, potential regulatory changes, and costs to developing CIRE projects throughout CA



Energy Research and Development Division
FINAL PROJECT REPORT

COMMUNITY INTEGRATED
RENEWABLE ENERGY PROJECT

Task 4: Energy Storage and Generation Analysis

Prepared for: California Energy Commission
Prepared by: Arup, for the San Francisco Department of the Environment

ARUP

JUNE 2014
CEC-500-2014-JUN

Please email SF Environment, Renewable Energy Program at renewables@sfgov.org if you would like a copy of the report

Conclusion

Credit: Luminalt

Solar Market Pathways

Solar+Storage for Resilience

SunShot
U.S. Department of Energy

Contact

Cal Broomhead
Climate/Energy Program Manager
415.355.3706
Cal.Broomhead@sfgov.org

Russell Carr
Senior Engineer, Electrical Group, ARUP
415.957.9445
Russell.Carr@arup.com

Terra Weeks
Renewable Energy Program Assoc.
415.355.3780
Terra.Weeks@sfgov.org

Jon Swae
SF Planning Department
415.575.9069
Jon.Swae@sfgov.org

SF Environment
Our home. Our city. Our planet.
SFEnvironment.org • (415) 355-3700
A Department of the City and County of San Francisco